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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Describes engineering tests of aircraft flares, surface flares, and photoflash cartridges. The procedures are also suitable for military potential tests, initial production tests, etc. Test phases include safety tests, environmental and handling tests, and performance tests. These test procedures do not apply to photoflash bombs or illuminating projectiles fired from artillery weapons or mortars.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-103
*Test Operations Procedure (TOP) 4-2-130
AD No.

24 August 1984

FLARES AND PHOTOFLASH ITEMS

1. SCOPE. This document describes engineering tests of aircraft flares, surface flares, and photoflash cartridges. The procedures are also suitable for military potential tests, initial production tests, etc. Test phases include safety tests, environmental and handling tests, and performance tests. These test procedures do not apply to photoflash bombs or illuminating projectiles fired from artillery weapons or mortars.

2. FACILITIES AND INSTRUMENTATION. Standard firing ranges and environmental facilities are required. Specialized equipment is covered under the subtests of paragraph 4 and references (TOPs, MTPs, other ref).

3. REQUIRED TEST CONDITIONS.

3.1 Initial Inspection. The test-item packaging is inspected for evidence of damage and deterioration. The name of the contractor, number of contract, date of manufacture, and other pertinent markings are recorded. The weight and dimensions of the package are also recorded. After unpacking, each item is inspected for damage and defects and pertinent dimensions and weight are recorded.

3.2 Sample Size. The sample size for safety testing will depend, as indicated in paragraph 4.1, upon a design review, the extent of prior testing, and the statistical reliability desired. TOP 4-2-504[1] and paragraph 4.6 will aid in this determination. Increased-severity testing is a factor that can reduce sample size. These same factors are considered in determining the number of items for environmental and shock tests and performance tests.

*Supersedes MTP 4-2-130 dated 23 November 1970.
[1]Numbers match those in Appendix B, References.
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3.3 Characteristics Data Sheet. A characteristics data sheet, suitable for the formal report and other uses, is assembled and printed. It consists of a photograph of the test item (exploded or cross-sectional view preferred) reduced in size and combined on a glossy 8- by 10-inch print, with a listing of all principal physical and performance characteristics. Guidance is provided in TOP 4-2-500.[2]

4. TEST PROCEDURES.

4.1 Safety Testing.

a. Safety testing is normally a first phase of the engineering test. The results of the tests are needed to aid in preparing a safety release prior to any testing by military personnel. Safety testing is also used in preparing a safety release if testing is to be conducted at a climatic test site. TECOM Supplement 1 to AR 385-16[3] should be followed in conducting a successful evaluation. It is also normally a part of the initial production test to meet the requirements of DARCOM Regulation 700-34.[4]

b. The approach to a safety test used in TOP 4-2-504 is applicable to flares and photoflash items. The safety testing of flares and photoflash items involves the following steps:

4.1.1 Design Review.

a. Study the design of the test item to determine which components have adequately proven themselves in designs of other pyrotechnics and which are relatively untried and deserving of more attention.

b. Study the test results of similar pyrotechnics and components to determine the extent to which these results may add to confidence in the safety of the flare or photoflash item.

4.1.2 Review of Prior Testing.

a. Review data from tests conducted by the design agency for use in the safety test. Such tests may include both field tests and laboratory tests, many of which may be in conformance with MIL-STD-331A.[5]

b. In addition, consider all field data from engineer design and other tests conducted at proving grounds in determining the statistical confidence in the safety of the item.

4.1.3 Safety Assessment Report. DARCOM Supplement 1 to AR 385-16 requires submission of a safety assessment report from the developer prior to initiation of development testing. Updated safety assessment reports may be requested for subsequent tests.

4.1.4 Safety-of-flight Release. A safety-of-flight release must be obtained from Aviation Research and Developement Command (AVRADCOM) prior to testing a particular flare or photoflash item from an aircraft.

4.1.5 Adequacy of Safety Features. Examine and manipulate external safety devices to ensure that they are adequate and not susceptible to accidental disengagement.

4.1.6 Adequacy of Manufacture.

a. Carefully inspect all items to be used in the safety test to ensure that they exhibit no observable flaws, and that there are no damaged or missing components.

b. Selected items may be subjected to X-ray examination as deemed necessary.

c. Record all observations.

4.1.7 Shock, Vibration, and Environmental Exposures. The number of test items selected for these exposures depends upon statistical considerations, cost and availability of test items, and amount of data available from prior testing of the same or similar items. The test items are subjected to certain standard transportation, rough handling, and climatic tests that simulate the extreme conditions that may be encountered. TOP 4-2-504 may be used for guidance on the number of test items that should be exposed to the various tests which follow.

a. High-temperature storage test.

(1) Subject packaged test items to a 7-day hot-dry cycling test in accordance with TOP 4-2-820.[6] This test simulates the hot-dry (A1) diurnal cycle of AR 70-38.[7]

(2) Sample size will be determined by the quantity per package.

(3) Following the test, examine the package for damage; open it, and examine the test items for damage.

b. High-temperature operating test.

(1) Expose the unpackaged test items from the high-temperature storage test for 24 hours to a temperature equivalent to the highest temperature that the items would realize if exposed to the solar radiation conditions described under the basic hot (A2) conditions in AR 70-38.

(2) This temperature may be obtained through measurements in a solar radiation chamber in accordance with TOP 4-2-826.[8] If this is impractical, a temperature of 63°C will be assumed to be the equivalent temperature.

(3) At the end of the exposure period, examine the test items for damage and exudation, and fire or launch all of them at the conditioned temperature.

(4) Record firing data described in paragraph 4.2.

NOTE: Most items being tested for hot environments are required to operate only under the basic hot (A2) conditions of AR 70-38. If a requirement exists for safety or satisfactory performance in a hot-dry environment, a test under simulated hot-dry solar radiation conditions, defined in AR 70-38 or a 71°C temperature equivalent, is conducted.

c. Low-temperature storage and operating test.

(1) Expose sample determined by packaged quantity for 3 days at -46°C.

(2) Examine the package for damage and the ability to withstand handling at low temperature.

(3) Unpack and examine the test items; recondition as necessary to -46 °C, and fire or launch them in accordance with paragraph 4.2.

NOTE: For test items that are required to operate in the basic cold conditions of AR 70-38, -46°C is required for safety purposes only. If the items are safe to fire at -46 °C but do not perform satisfactorily, a later test is conducted at -37°C to evaluate performance under cold conditions.

d. Secured-cargo vibration test.

(1) Vibrate approximately 48 packaged test items at 63°C, and vibrate 24 packaged test items at -46°C to simulate transportation in trucks, trailers, and aircraft as provided in TOP 1-2-601.[9]

(2) Following inspection, fire or launch the test items at the test temperatures in accordance with paragraph 4.2.

e. Rough handling test.

(1) Expose approximately 48 test items to the sequential rough handling test described in TOP 4-2-602.[10] The test includes a 2.1-m packaged drop test, a loose cargo test, and a 1.5-m unpackaged drop test.

(2) After inspection, fire or launch all test items at the test temperatures in accordance with paragraph 4.2.

f. Twelve-meter packaged drop test.

(1) Drop two to six packages of test items in accordance with TOP 4-2-601.[11]

(2) Preferably the test items will have most explosive components removed in advance to permit complete inspection to determine the nature and degree of damage to both the packaging and test samples. (See TOP 4-2-601.)

(3) In some instances, the packages are removed from the drop location with remote handling equipment for assurance that such a drop and subsequent handling will not cause detonation and that the items are safe for disposal.

g. Radio-frequency (RF) hazard test. Conduct this test according to requirements documents but only for electrical or electronic fuzes or electrically initiated items. Otherwise test according to the RF specifications for each type of test item.

h. Static electricity test. Conduct this test in accordance with TOP 1-2-511.[12]

i. Electromagnetic radiation test. Conduct this test in accordance with TOP 1-2-511.

4.i.8 Supplementary Environmental and Shock Tests. From the tests below the test director will select those that he deems necessary considering requirements documents, potential use, and prior testing on the same or similar items. He

will normally expose some of the test items to sequences of extreme environments which the materiel could encounter during its life cycle. Appendix A of MTP 4-2-015[13] provides a general approach to sequential testing. These environments may include those of 4.1 above. One sequence would assume that the item will be sent to the arctic, another that the item will be sent to the tropics, and another that it will be sent to the desert. After each exposure all items are examined and a representative sample test fired. The remainder are sent through the next environment of the sequence.

a. High and low operating temperatures. If the test items proved to be safe but failed to perform satisfactorily at either the "hot-dry" or "cold" temperatures of the safety test (para 4.1), but are required to meet only the intermediate temperature requirements of AR 70-38, conduct additional performance tests at the high and low temperatures as described in paragraphs 4.1.7b and c.

b. Solar radiation. This test is primarily for heat effects.

(1) Expose the test items to the intermediate solar radiation conditions of AR 70-38, in the manner prescribed in MIL-STD-810D.[14]

(2) Test is of 5 days' duration.

(3) After 5 days examine test items.

(4) Fire at the equivalent peak temperature. (See TOP 4-2-826.)

c. Salt spray (fog). The purpose of this test is to determine the corrosive effect of an ocean environment; conduct in accordance with MIL-STD-810D.

d. Fungus resistance. If an actual exposure to fungus is determined to be necessary, conduct the test as described in MIL-STD-810D.

e. High humidity. Conduct in accordance with TOP 4-2-820.

f. Water immersion.

(1) Condition the test items to 44°C.

(2) Immerse in water at 18°C.

(3) Leave for 2 hours under 0.9 m of water. (This is the leakage test of MIL-STD-810D.)

g. Sand and dust. Conduct sand and dust tests in accordance with MIL-STD-810D.

h. Rain and freezing rain. The water immersion test is usually adequate to replace rain, but conduct the freezing rain test in accordance with TOP 2-2-815.[15]

i. Temperature shock.

(1) Conduct this test in accordance with MIL-STD-810D, Method 503.2, except that the high temperature will be in accordance with that for the high-temperature operating test described in paragraph 4.1.7b.

(2) Low temperature will be -46°C.

(3) Maximum time for transfer between chambers will be 30 seconds.

j. Air transportability.

(1) Place the test item in an altitude chamber.

(2) Reduce pressure to simulate a 15,240-m (50,000-ft) altitude, and reduce the temperature to -54°C.

(3) Hold conditions for 2 hours.

(4) After 2 hours restore ambient conditions as quickly as facilities permit.

k. Air delivery. Test packaged airdrop items in accordance with TOP 7-2-509[16] and TOP 4-2-509.[17]

l. Safety tests regarding noise, light, chemicals, etc. Conduct these subtests in accordance with MTPs 4-2-132[18] and 4-3-148.[19]

m. Human factors test. Determine man-item interaction in accordance with MTP 4-3-148.

4.2 Performance Tests, Photoflash Cartridges.

4.2.1 Static Test. The purpose of the static test is to determine the light output of the illuminating charge. (See MTP 4-2-132.)

a. Method. Cartridges modified for static firing must be provided by the manufacturer.

(1) Suspend the cartridge 4.6 to 7.6 m above the ground on a line tied between two poles. The exact height depends on the distance required between the cartridge and the light sensors which are placed on the ground.

(2) Employ one or more sensors depending on the number of positions, relative to the cartridge, at which the light output is to be measured.

NOTE: Use photoelectric cells to detect the flash of the cartridge. Each photoelectric cell has two outputs, a digital integrating voltmeter and an oscilloscope. The digital integrating voltmeter indicates the light output in terms of the "light integral" when a suitable calibration factor is applied. The oscilloscope indicates light intensity with respect to time. The vertical deflections of the electron beam can be converted to light intensity by applying a calibration factor. The horizontal sweep rate is controlled by a time-base generator and, therefore, provides a time reference. A polariod camera photographs the trace on the screen to provide a permanent record of the data.

b. Data required. The test results are expressed in terms of the light integral, which is the integral of light intensity with respect to time, over the illumination time span. This value is obtained from the digital integration voltmeter by application of a calibration factor. As a backup, the light

integral may be obtained from the trace of light intensity versus time by measuring the area under the curve.

4.2.2 Ejection Test. The object of this test is to determine whether the cartridge will function and to determine the fuze delay.

a. Method. This test involves actual firing of the cartridges from a ground-based projector.

(1) Orient the projector to fire at an elevation angle of approximately 55°.

(2) Place a photoelectric cell downrange of the launcher but away from the line of fire.

(3) Direct it toward the area where the flash of the illuminating charge should occur.

(4) Shield it from the direct rays of the sun and the muzzle flash of the projector.

NOTE: The fuze delay of photoflash cartridges is of such short duration that an electric counter (capable of measuring time durations as short as 0.0001 second) must be used to record it. The counter receives its start impulse when voltage is applied to the firing circuit of the projector. The stop pulse is provided by the photoelectric cell when the flash of the illuminating charge occurs.

b. Data required. Record the following:

(1) Number of duds.

(2) Fuze delay of those rounds which function.

4.3 Performance Tests, Aircraft Flares.

4.3.1 Surface Tests. Surface tests of aircraft flares are usually limited to providing assurance that the fuze will function properly with the proper delay, not only under ambient conditions, but at the extreme temperatures and following the environmental exposures stipulated in the safety tests.

a. Method. The assurance of proper fuze functioning is required to be certain that it is safe for testing aloft where, because of the extended drop required, most of the testing must be done. The amount of testing performed on the ground will depend upon the amount of usable data already available from prior testing. Ground tests do not use live flares.

b. Data required.

(1) Environmental exposure prior to functioning.

(2) Temperature at time of functioning.

(3) Fuze delay (measured with a stopwatch and reported to 0.1 second).

NOTE: Information on the intensity of flares is usually provided to the proving ground by the developing agency. If there is a requirement that such information be obtained by the proving ground, however, it will be obtained statically in the manner described for photoflash cartridges (para 4.2.1).

4.3.2 Flight Test. Before testing aloft, a safety-of-flight release must have been received (para 4.1.4), the fuze must have displayed no short delays during surface testing (para 4.3.1), and a check must have been made (with inert flares on the ground) of the compatibility of the aircraft's dispensing system with the particular flare under test.

a. Equipment - The type of aircraft, altitudes, and air speeds are governed by the requirements documents. If the altitude at which candle ejection and ignition occur is to be determined, this can be accomplished by observing the flare by cinetheodolite. (See MTP 5-1-031.[20]) Testing of aircraft flares, however, generally consists of timing each event with a manually operated stopwatch.

b. Fuze delay - Measure the time from launch to ejection of the candle from the flare body with a stopwatch accurate to 0.01 second, and record to the nearest 0.1 second. To accomplish this, the pilot of the aircraft gives a countdown, by radio, to an observer on the ground. On the pilot's command, the flare is launched, and the observer starts the watch. The observer stops the watch upon visually observing candle ejection.

c. Burning time - An observer on the ground times the burning of the candle from ignition until the light is no longer visible. The time is recorded to the nearest second. Notes should be made whether the candle burned out in the air, burned out on the ground, drifted out of sight, etc.

d. Other data - Notes should be made of malfunctions such as failure of the parachute to deploy, late ignition of the candle, shroud lines becoming detached, etc. It may be necessary to measure and record other times in the sequence of events, such as the delay from ejection of the candle until ignition of the candle, ejection of the candle until deployment of the parachute, etc. The need for such information depends upon the performance requirements set forth in the applicable guidance documents.

e. Tests following environmental exposures - The above in-flight tests are employed not only for ambient conditions but for performance tests following the environmental exposures of paragraphs 4.1.7 and 4.1.8. For performance data under high- and low-temperature conditions, it is necessary to minimize the length of time between the time of removal from the temperature box and the time of dispensing from the aircraft. The use of improvised temporary thermal insulation is advisable.

4.4 Performance Tests, Surface Flares. Flares exposed to environmental conditions of paragraphs 4.1.7 and 4.1.8 and those tested at ambient conditions will all be tested for performance in accordance with tests below. The testing of surface flares varies, however, depending upon the type of flare and method of activation.

a. Stationary surface flares - Time the duration of burning, and record observations on the intensity of flare, steadiness of burning, etc.

b. Launched surface flares - As applicable, record the following: angle of launch, fuze delay, duration of burning, maximum height reached by the flare, observations on intensity and steadiness of the flare, observations of parachute performance, and height at time of burnout. Additional times and events such as height at parachute deployment and time of first burning can be recorded as needed. needed.

c. Flares with trip wires - In addition to data of a or b above, measure the force to function the flare to the nearest 0.44 N (0.1 lb) with a pull-type spring scale.

4.5 Vulnerability. When a vulnerability test (sometimes called a bullet impact test) is required, conduct the test using 7.62-mm and cal .50 projectiles fired at close range at service velocity.

a. Method.

(1) Fire upon several test items, unpackaged and grouped, with several types of ammunition.

(2) Satisfactory performance requires that the test items not detonate or ignite, and that they be safe to dispose of.

b. Data required.

(1) Number and types of projectiles.

(2) Location of each impact.

(3) Appropriate photographs and description of results.

4.6 Reliability. When a reliability requirement is stated, MTP 3-1-002[21] is used to determine whether the desired reliability was achieved with the desired confidence. A precise definition of satisfactory performance is a prerequisite to a reliability analysis. Make two reliability analyses:

a. Overall reliability which includes a summation of all of the satisfactory and unsatisfactory samples of each subtest.

b. Selected reliability which includes all sample groups except those in which the test items suffered damage or deterioration during environmental or rough handling tests and groups in which statistically significant failures occurred in a particular subtest.

5. DATA REQUIRED. On a round-by-round basis, record the following:

a. All exposure conditions.

b. Performance characteristics of paragraphs 4.2, 4.3, and 4.4.

c. Conditions of launch.

d. Significant weather conditions.

e. Other observations.

6. PRESENTATION OF DATA.

a. Determine the mean and standard deviations of all numerical values for each parameter measured.

b. Determine the effect of environmental exposures and make an evaluation against the requirements documents or specifications.

c. State the results of the safety test.

d. Note any temperature or handling limitations.

e. Make a statistical comparison between the reliability of the test item and that of the control item, particularly if the control item is a standard item being replaced by the test item.

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APPENDIX A
BACKGROUND

Flares and photoflash items are pyrotechnic devices used for illumination. Flares provide illumination of relatively long duration, 1 to 3 minutes, for visual observation and reconnaissance. They are divided into two categories, aircraft flares and surface flares. Aircraft flares are launched remotely from fixed-wing aircraft using a rack, and from rotary-wing aircraft manually using either a static line or dispenser. A parachute is usually employed to prolong airborne time. Surface flares are generally stationary, although some are contained in their own disposable launchers which are used to project them above the area to be illuminated.

Photoflash cartridges provide illumination of short duration (fraction of a second) for photographic reconnaissance. They are used exclusively on aircraft and are fired from a multibarreled projector on an outer-case-type projector.

APPENDIX B
REFERENCES

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